



Advances in Unrepeatered Submarine Systems



XTERATM

NANOG45

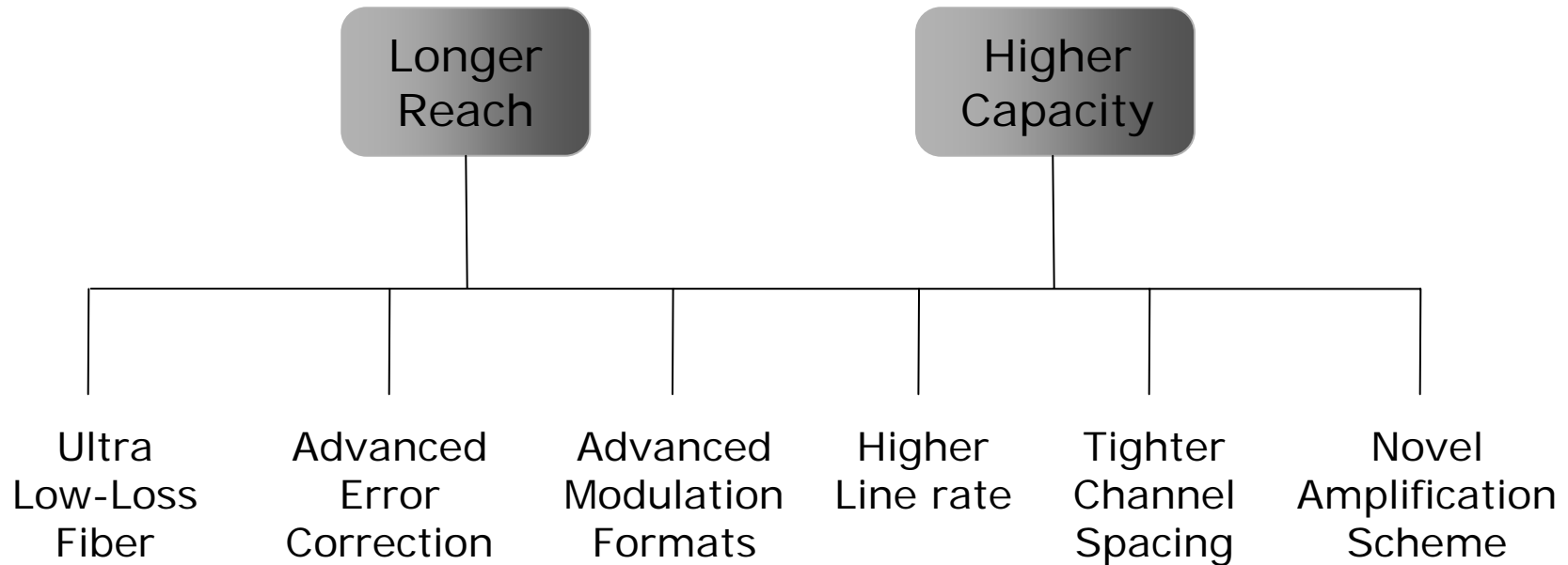
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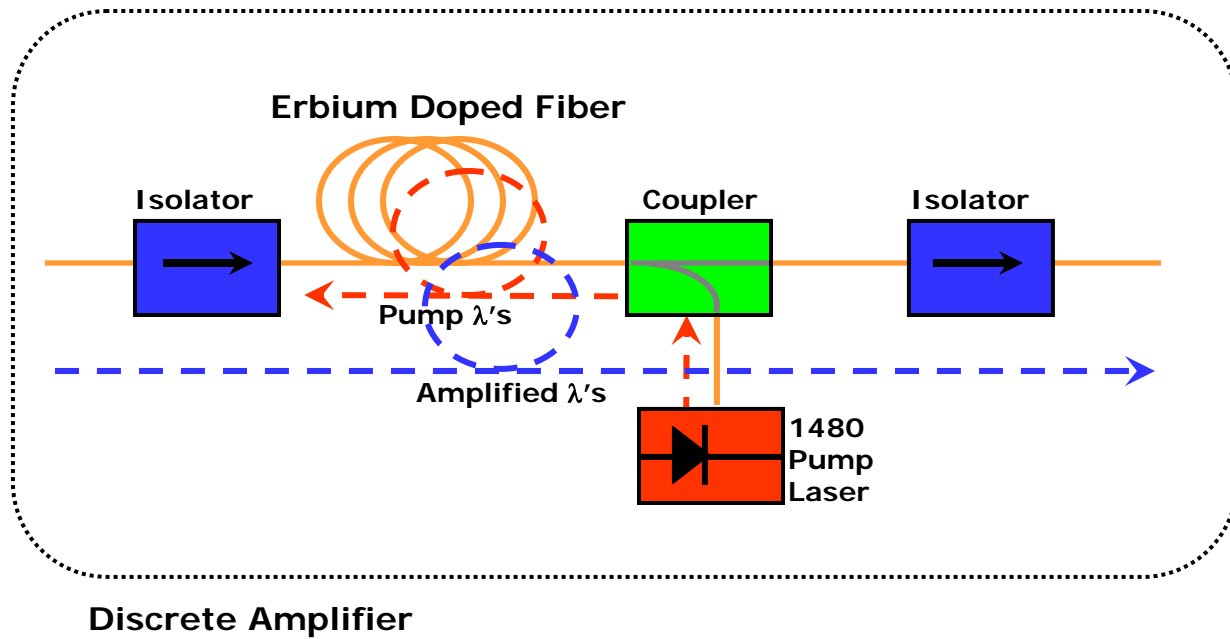
Outline

- Status of un-repeated technology
- Advances in un-repeated submarine technologies
- Applications
 - Extending the life of existing systems
 - Longer reach
 - Higher capacity

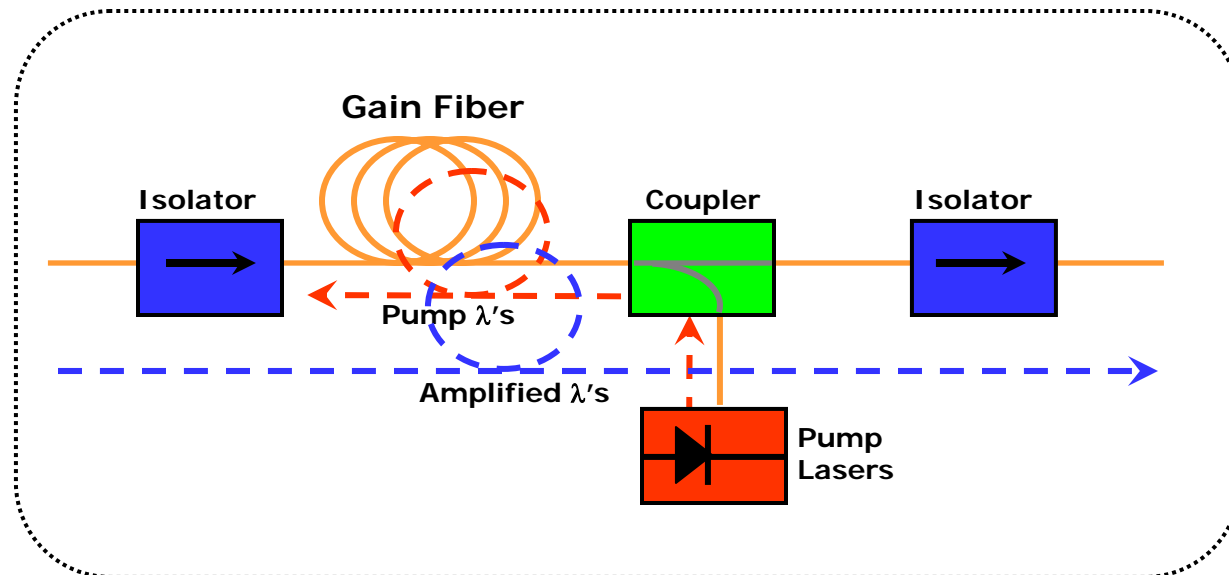
Technologies for Longer Reach & Higher Capacity



Amplification

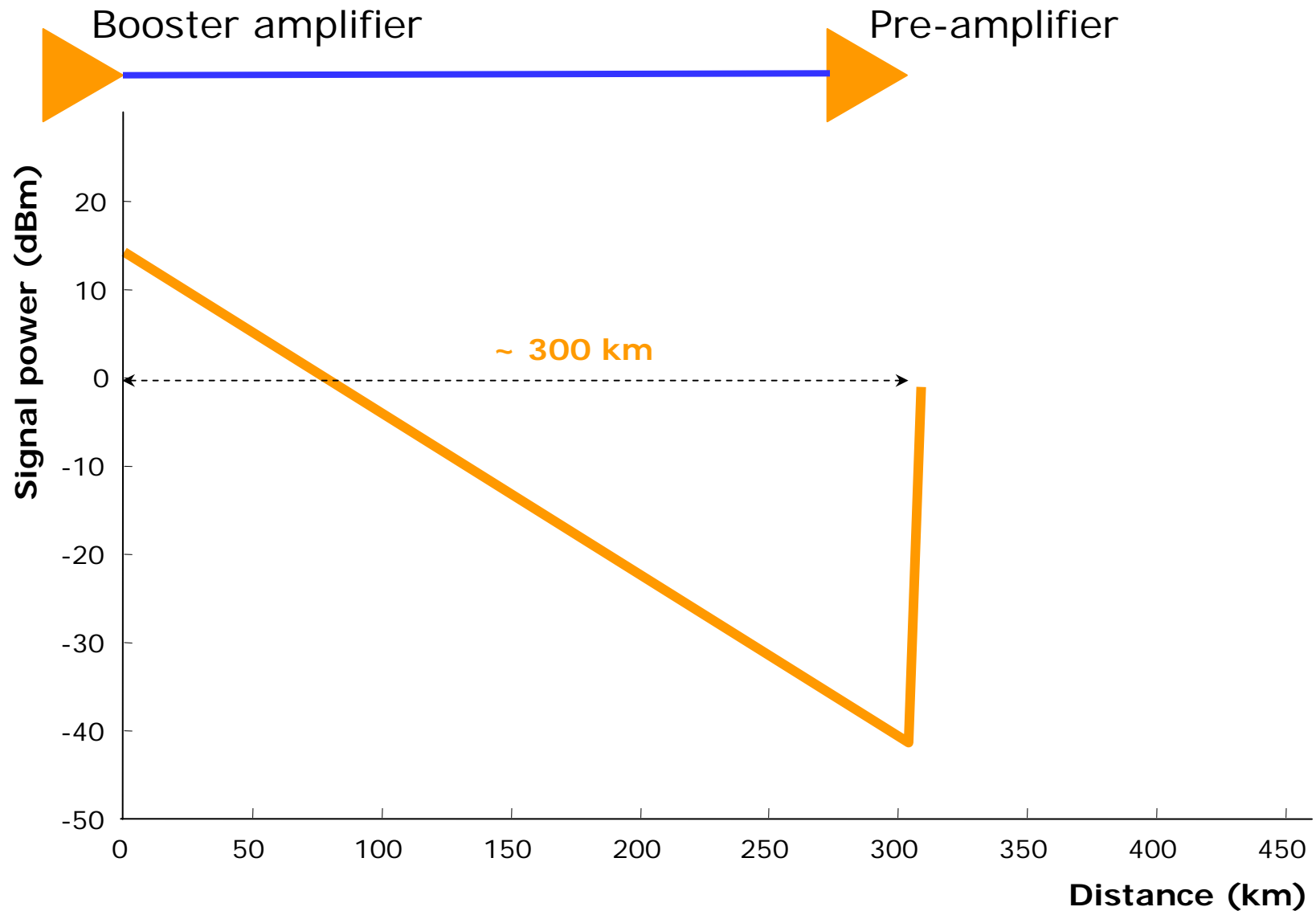


Discrete Raman Amplifier

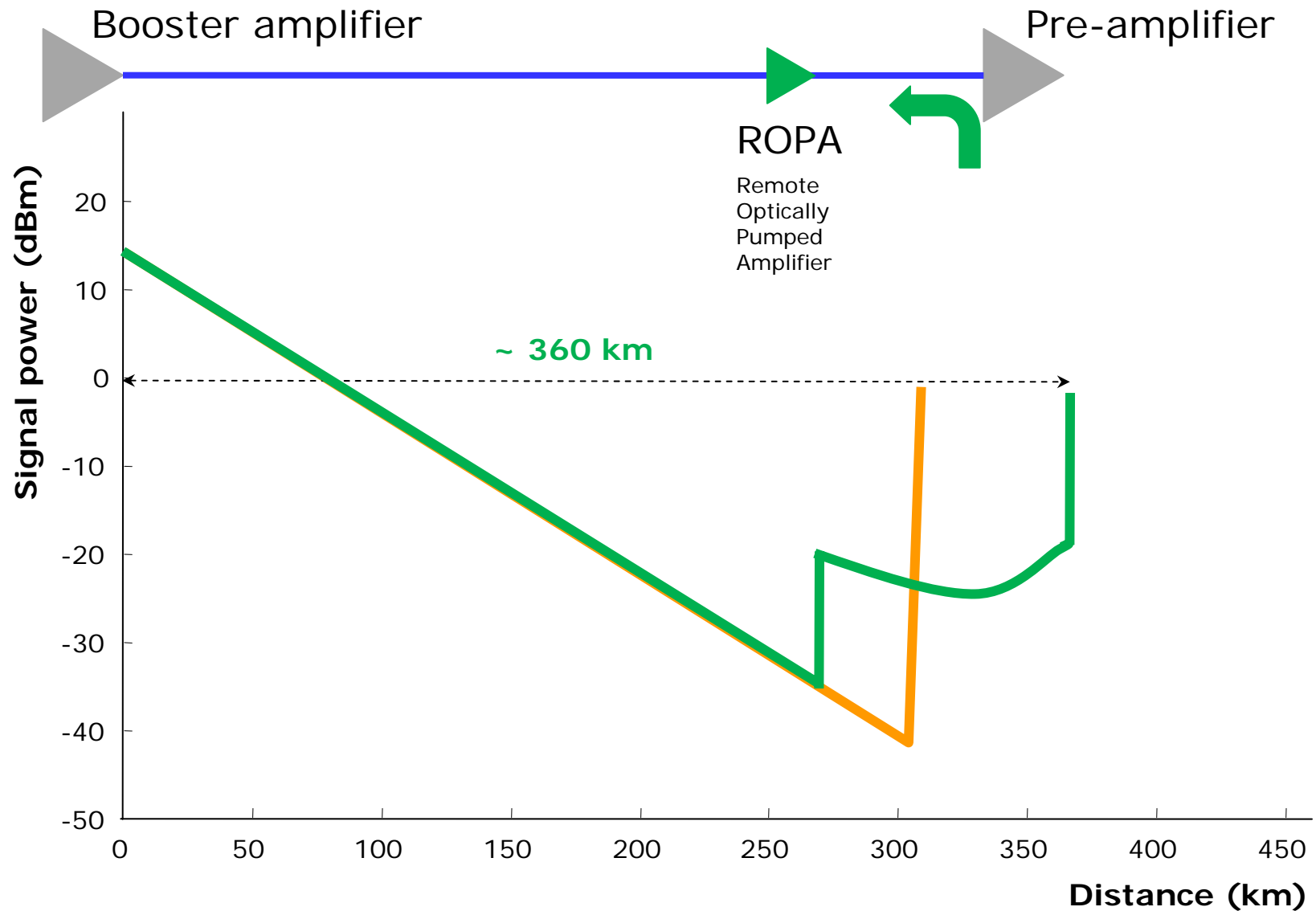


Discrete Raman Amplifier

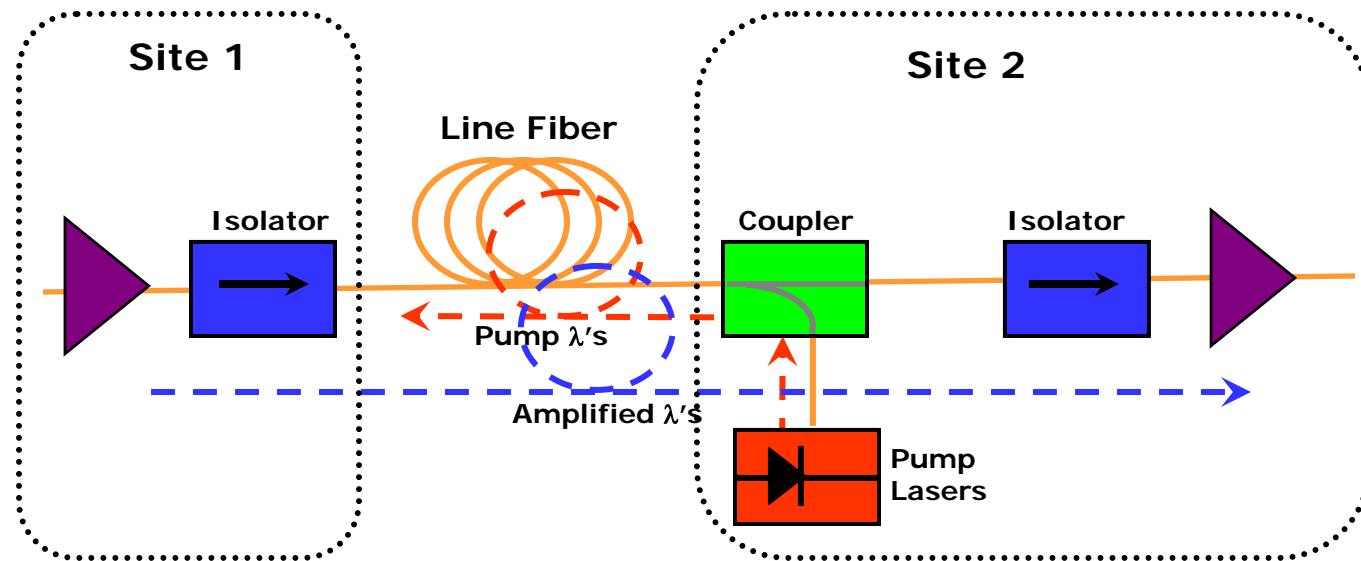
Status of Un-Repeated Submarine Systems (1)



Status of Un-Repeatered Submarine Systems (3)



Distributed Raman Amplification



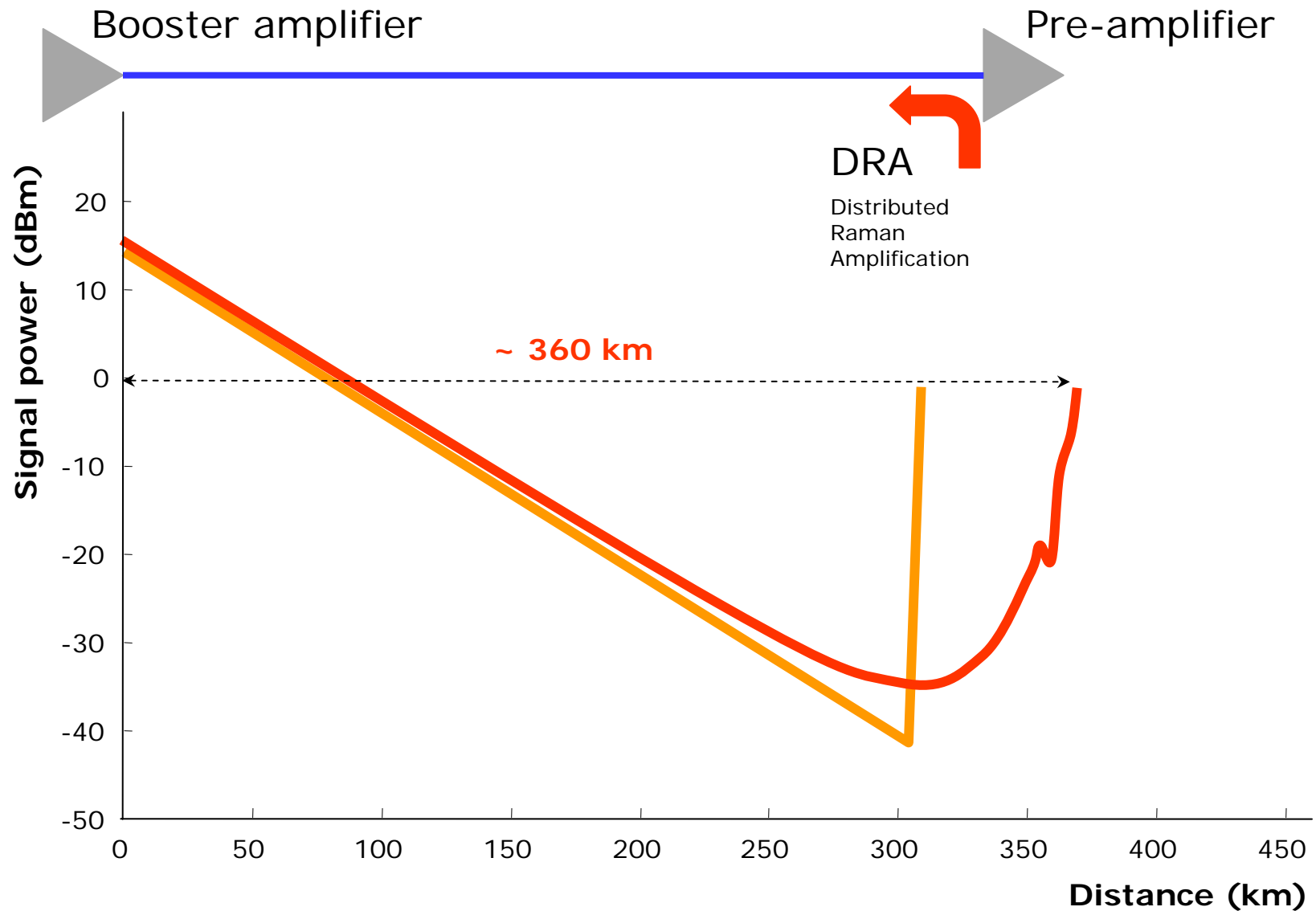
Distributed Raman Amplification

Uses the transmission fiber between amplifier sites as the gain fiber

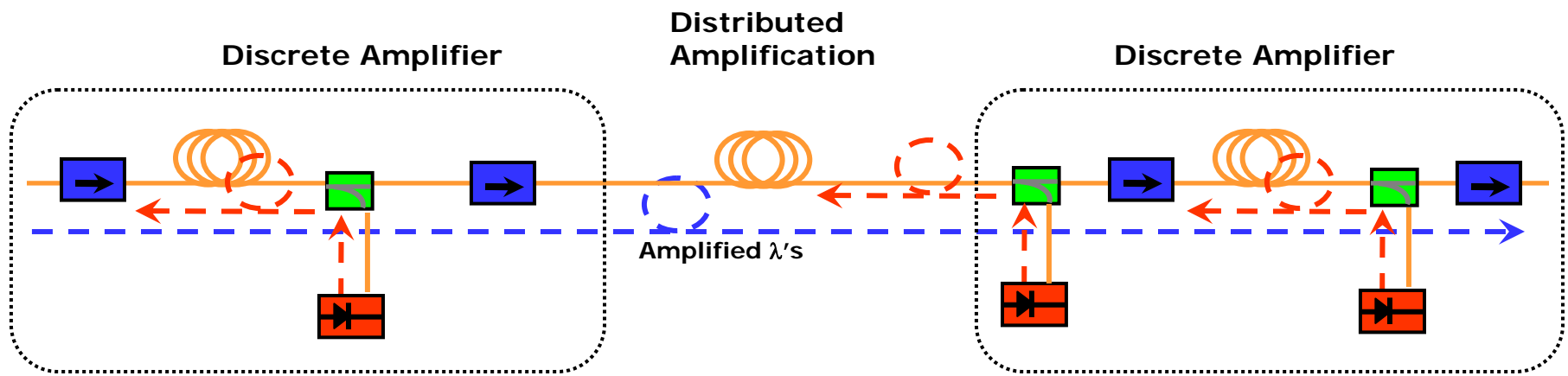
Benefits

- Improved noise figure & reduced non-linear penalty
- Longer amplifier spans, support of higher line rates, operation near zero dispersion wavelength

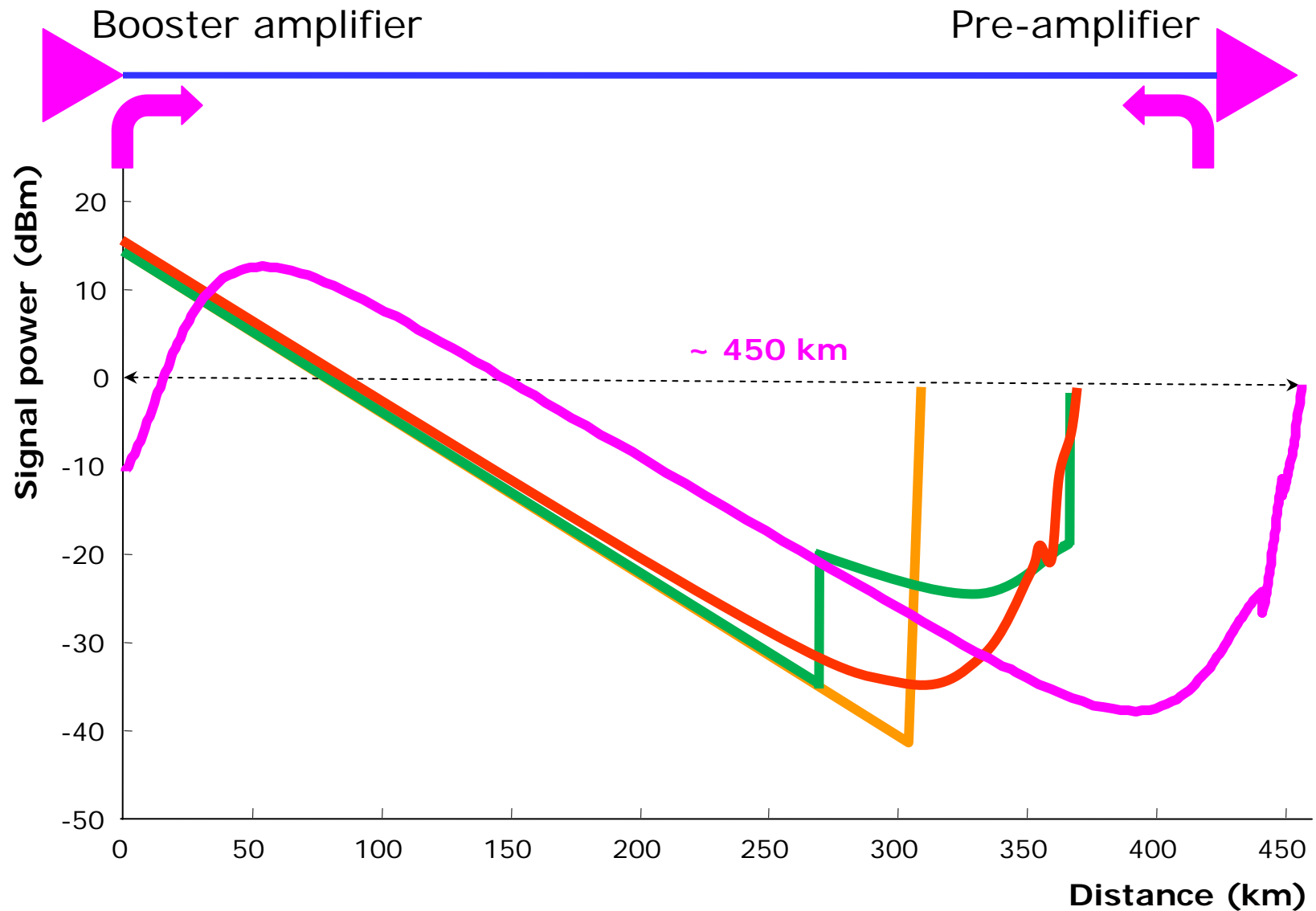
Status of Un-Repeatered Submarine Systems (2)



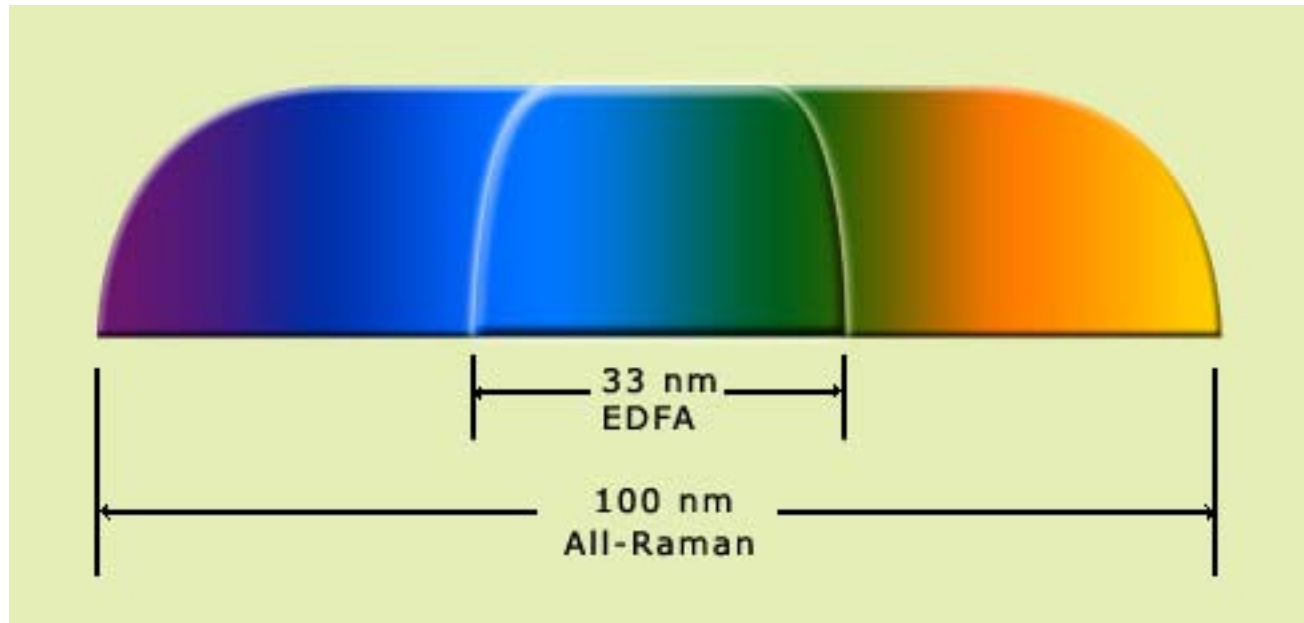
All Raman Amplification



Improved Reach with All-Raman Amplification

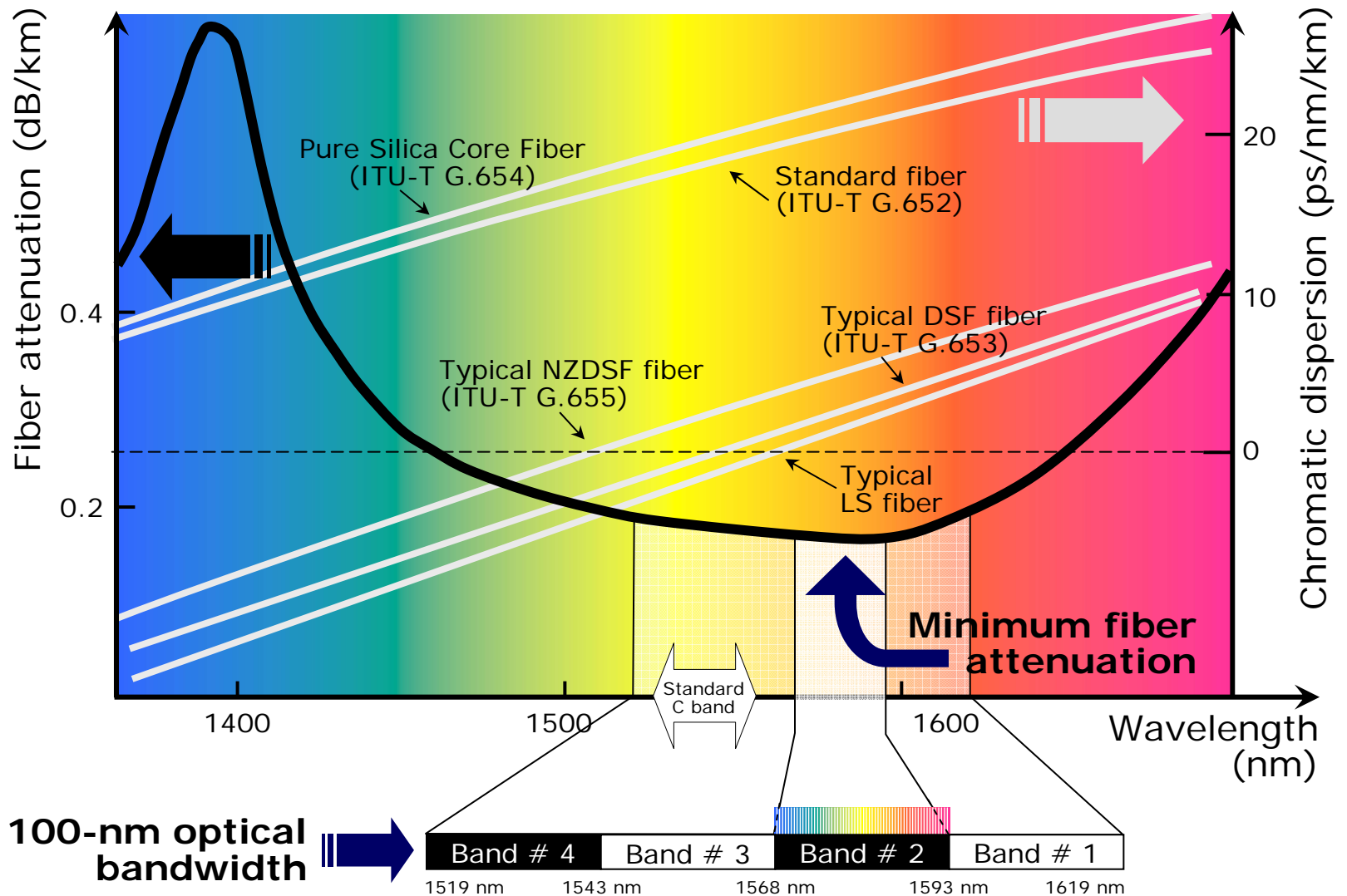


Improved Capacity with All-Raman

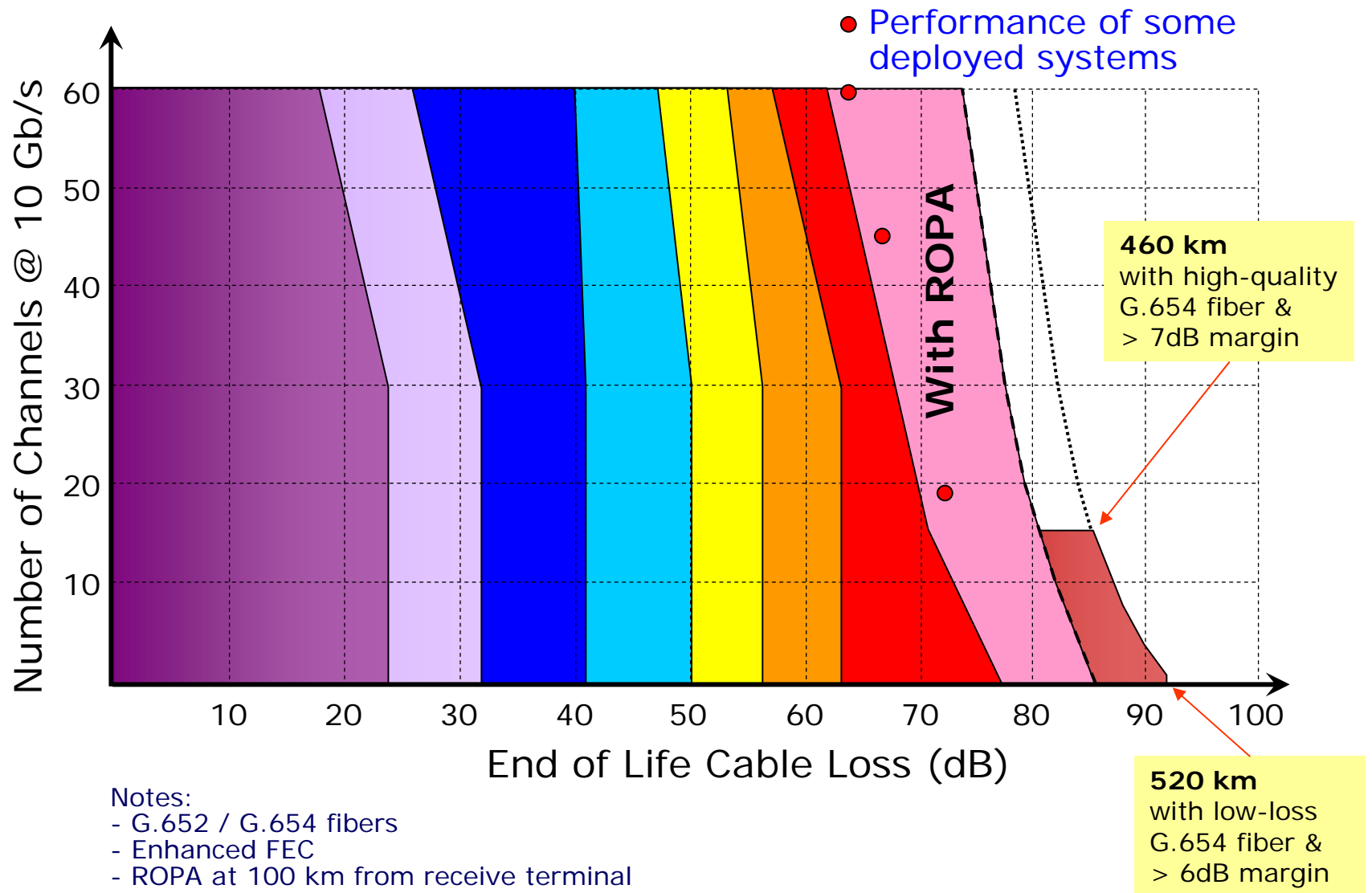


All-Raman technology allows cost-effective combinations of **reach** and **channel count** that are unattainable in erbium-based systems

Optical Bandwidth vs Fiber Spectral Characteristics



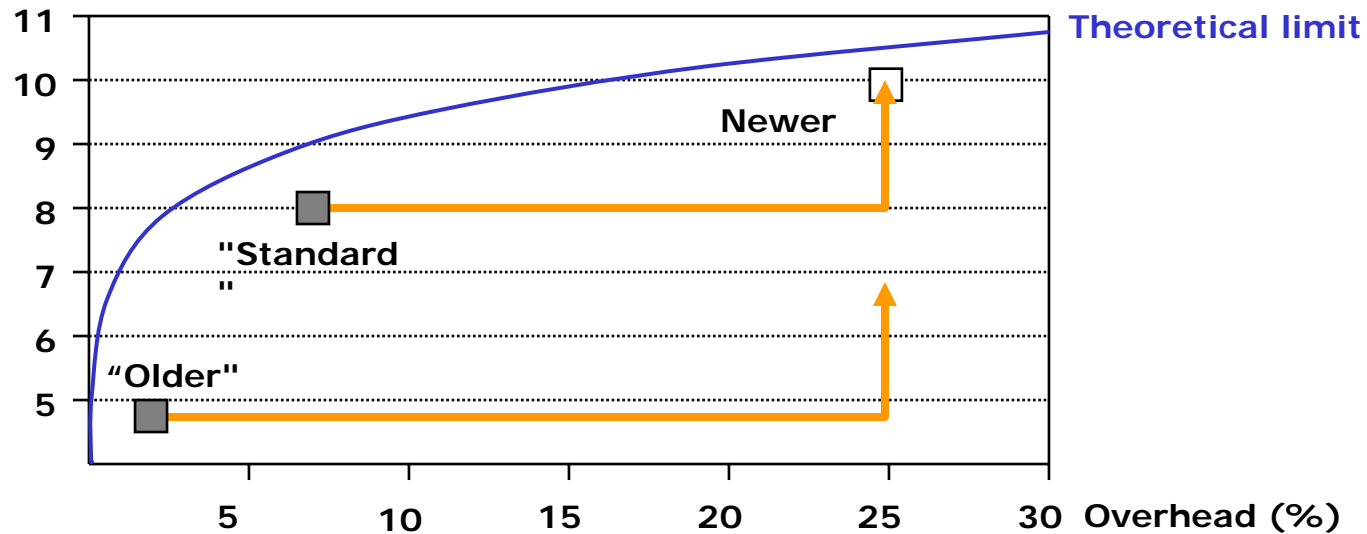
All-Raman Enabled Distance & Capacity



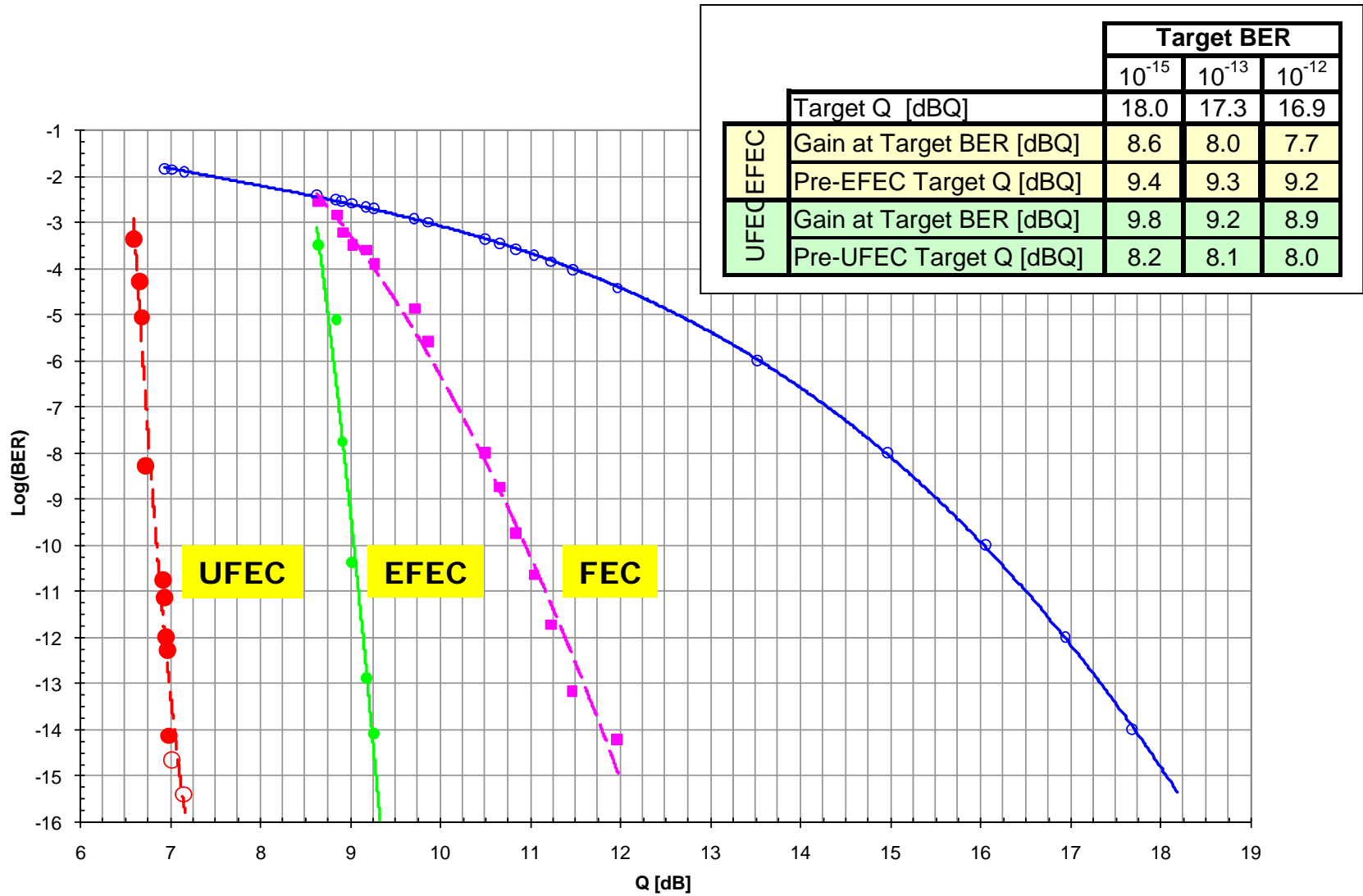
Advanced Error Correction

- FEC, EFEC, UFEC
- Upgrades to older systems have up to 6 dB effective gain
- Even on standard systems effective gain of up to 2 dB by going from 7% to 25% overhead

Net coding gain
(dB)

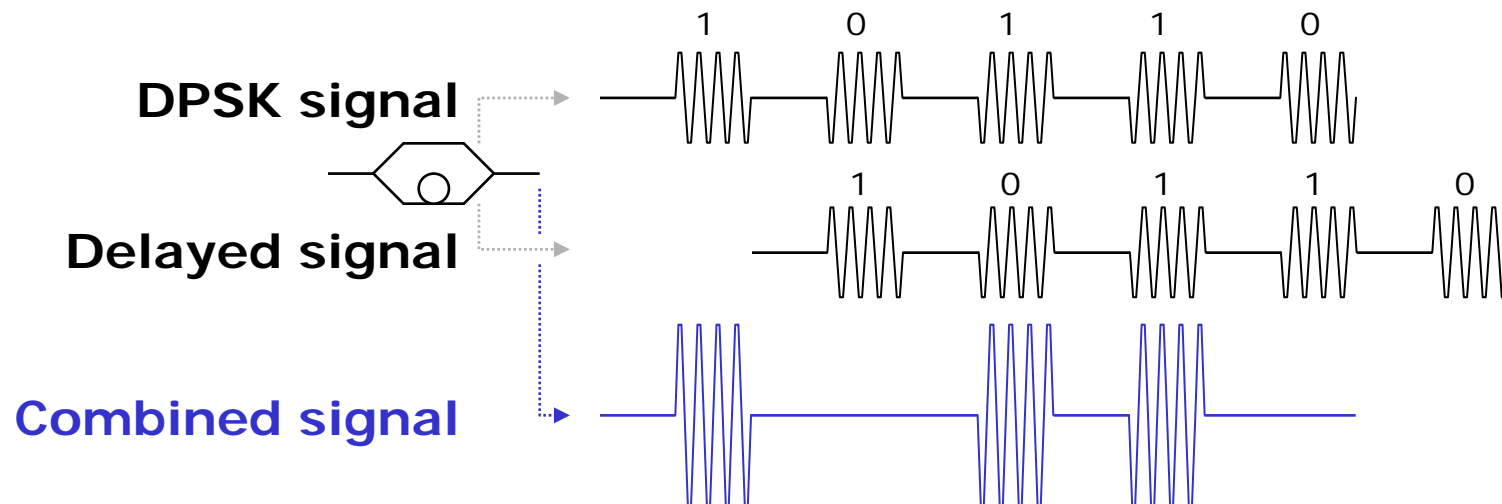


UFEC Performance



Advanced Modulation Formats

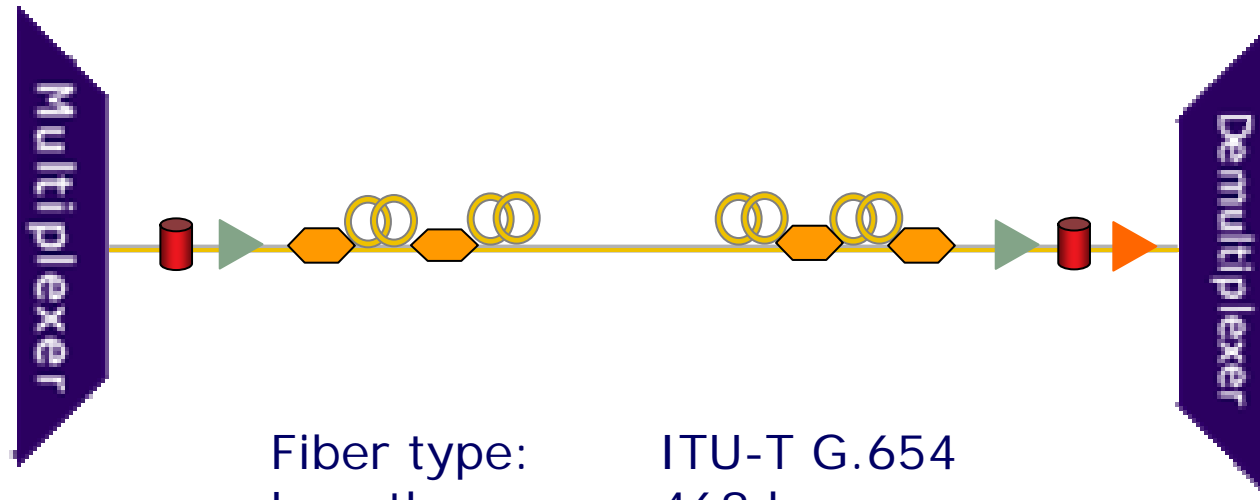
- DPSK = Differential Phase Shift Keying
 - Encoding:
 - "1": phase is the same as previous bit
 - "0": phase is inverted
 - Detected by splitting and re-combining after one bit delay



Quasi-coherent detection; gives ~ 3 dB improvement

Higher Line Rate

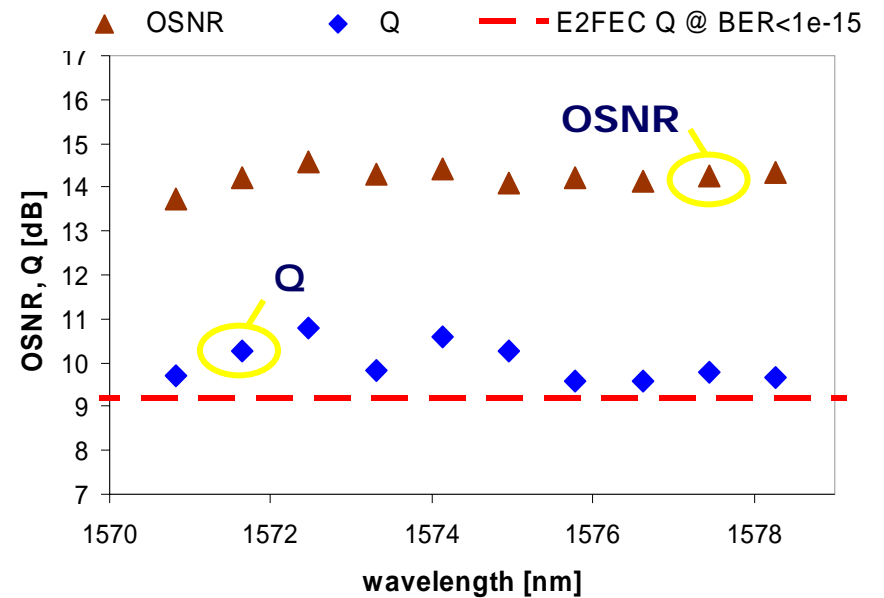
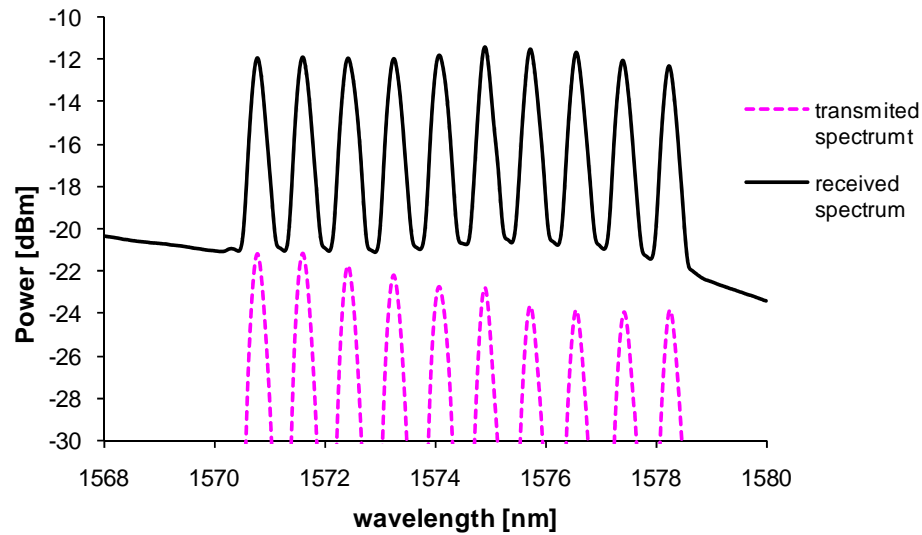
- 40Gb/s transmission



Fiber type: ITU-T G.654
Length: 468 km
Loss (@ 1550nm): 82 dB
ODF scenario: Splices
Line rate: 43Gb/s
Modulation format: NRZ-DPSK

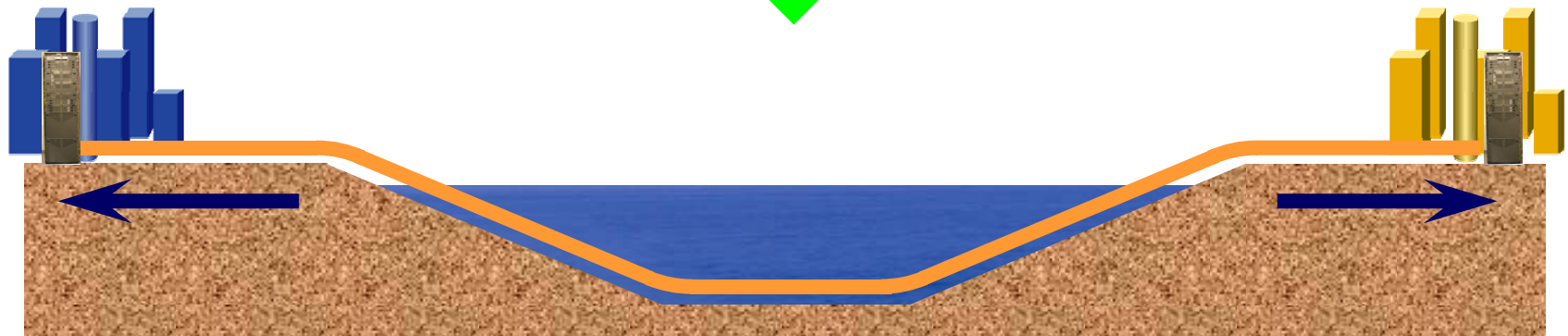
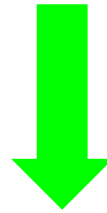
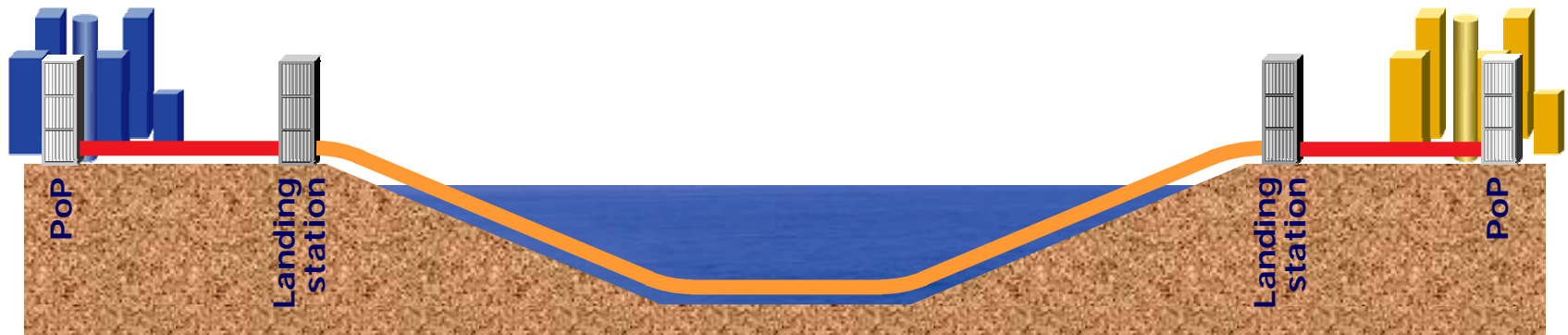
Transmission of 10ch at 40G over 468km (82dB)

Spectra



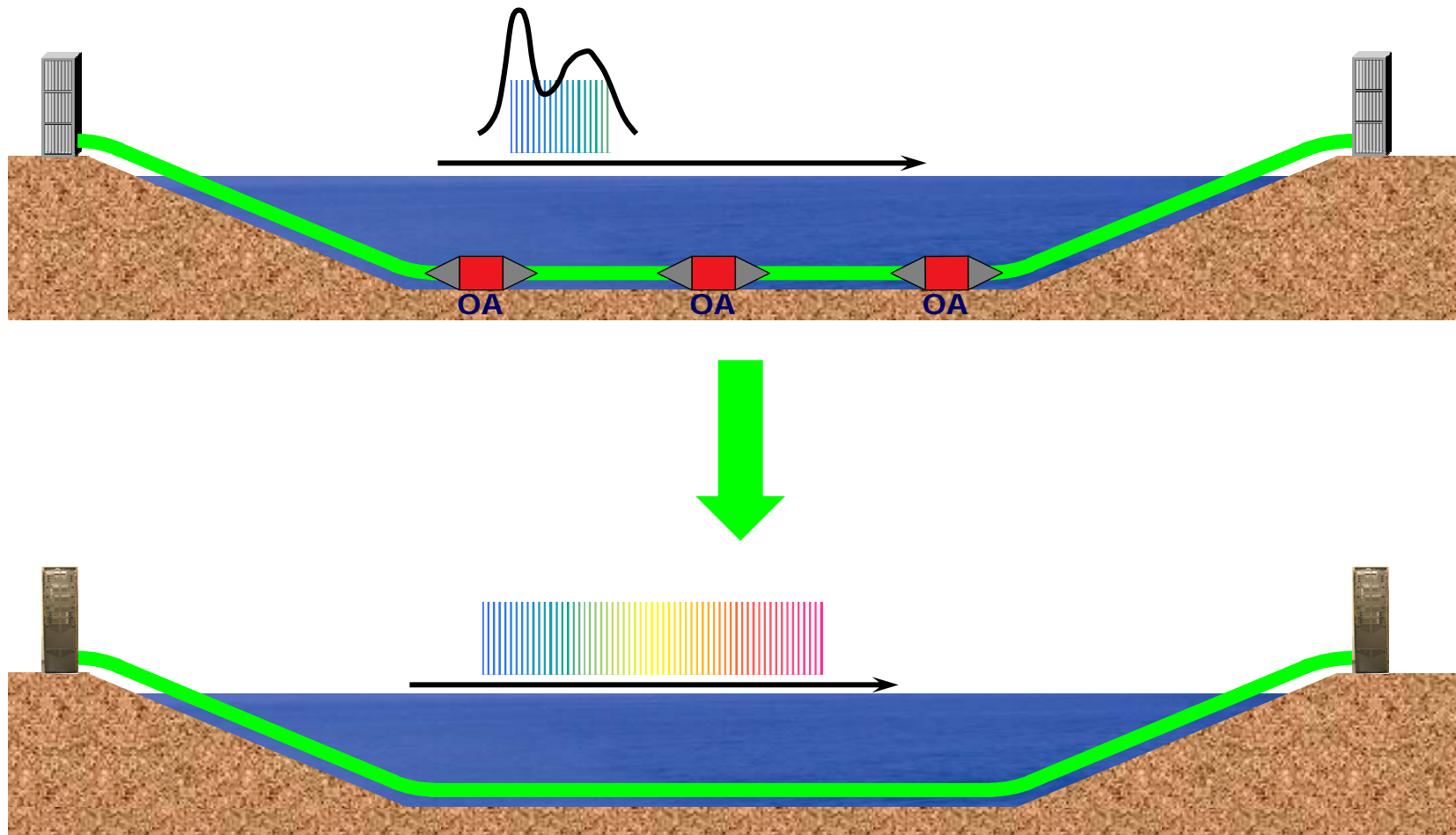
Design Simplification (1)

Placement of SLTE in PoP



Design Simplification (2)

Upgrade of older generation systems



ARCOS Upgrade



- 22 unrepeated segments
 - 10 with ROPAs
- Longest=394km (with ROPA)
- Highest loss=78.4dB (EOL)
 - Max capacity=23x10G
- 5 to 11x capacity increase

THE COLUMBUS NETWORKS FIBER SYSTEM

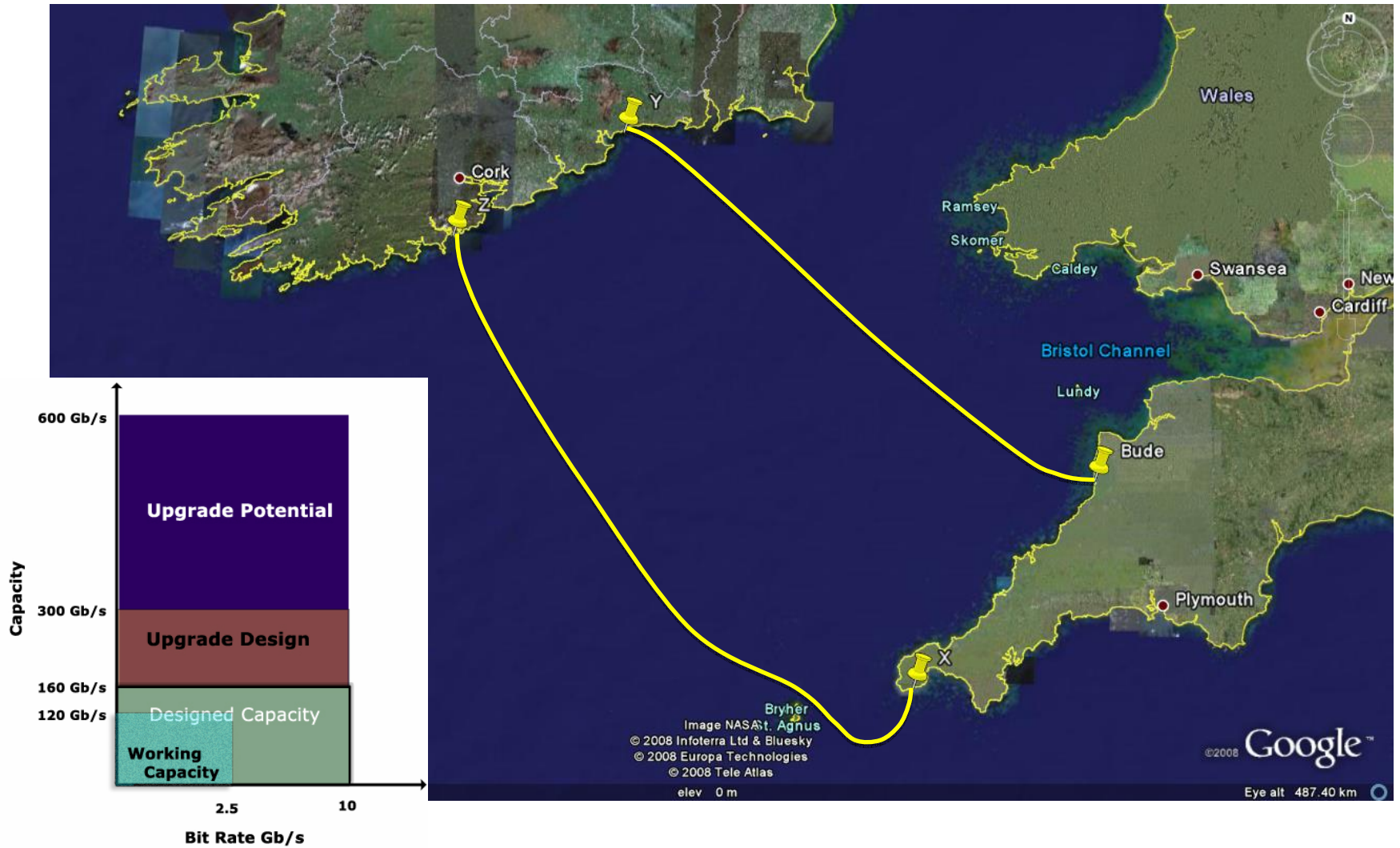
Connecting the Americas



www.columbus-networks.com



Irish Ring





Summary

- Submarine Fiber Systems vital to continued globalization
- Unrepeated Submarine systems pivotal for both intra-regional and global connectivity
- Novel Amplifier design using All-Raman amplifications continues to push the limit for distance and capacity
- A key benefit of all-Raman is the ability to upgrade existing unrepeated and short repeated links